<u>REMARKS</u>

I. <u>Introduction</u>

In response to the Office Action dated July 7, 2009, claims 1-16, 18-19 and 26-26 have been canceled, claims 17, 20 and 24 have been amended, and new claims 27-34 have been added. Claims 17, 20-24 and 27-34 are in the application. Re-examination and re-consideration of the application, as amended, is requested.

II. <u>Claim Amendments and Cancellations</u>

Applicants' attorney has canceled claims 1-16, 18-19 and 25-26, and amended claims 17, 20 and 24, solely for the purposes of expediting prosecution in this application and clarifying the language of the claims. However, these cancellations and amendments were not required for patentability or to distinguish the claims over the prior art. Moreover, Applicants reserve the right to re-introduce these claims in this or follow-on applications.

Support for the amendments to claim 17 can be found in Applicants' specification at the following locations:

> <u>With regard to "cones having a size not smaller than 200 nm," see Applicants' specification at page 11, line 20:</u>
> The cone-shaped surface appears very effective for light extraction from the LED. Moreover, experimental results suggest that a cone shape can extract more light. **For example, the wavelength of a blue LED in a GaN crystal is about 200 nm. If the size of the cone shape is much smaller than that value, then the light might not be affected by the roughness. On the other hand, if the size of the cone shape is close to that value, the light might be scattered or diffracted.**
>
> <u>With regard to "increase extraction efficiency … as compared to the N-face surface without the cones," see Applicants' specification at page 4, line 5:</u>
> On the other hand, in the present invention, utilizing flip-chip technology [14] and the LLO method, a substrate-free nitrogen (N) side-up GaN-based LED structure can be made. **Thereafter, an anisotropic etching process can be used to roughen the surface of the N-side-up GaN-based LED. This results in a hexagonal "cone-like" surface, which is beneficial for light extraction. Extraction efficiency of an optimally roughened surface LED shows an increase by more than 100% compared to an LED before roughening.**

Consequently, Applicants' attorney submits that these amendments are fully supported by the specification as original filed.

III. Telephone Interview Summary

Record is made of telephone interviews between Examiner Jackson and Applicants' attorney that took place on July 24, 2009; August 11, 2009; August 19, 2009; August 24, 2009; August 26, 2009; and September 1, 2009. The prior art and the claims were discussed, but no agreement was reached as to allowable claims.

IV. Non-Art Rejections

On pages 2-4, the Office Action rejected claims 1-26 under 35 U.S.C. §112, first and second paragraphs.

Applicants' attorney has canceled some of the claims, has amended others of claims to overcome some of these rejections, but traverses others of the rejections as set forth below.

With regard to the rejection of claims 1-16, 25 and 26 under 35 U.S.C. §112, first paragraph, as failing to comply with the written description requirement, because there is allegedly no original support for the language "each of the cones is at least the size of the wavelength of the light extracted through the surface," Applicants' attorney traverses theses rejections but has canceled claims 1-16 and 25-26.

With regard to the rejection of claims 1-26 under 35 U.S.C. §112, second paragraph, as lacking an antecedent for "the nitrogen face (N-face) of the LED" and "the wavelength of light," Applicants' attorney has canceled claims 1-16, 18 and 25-26 and has amended claim 17 to overcome these rejections.

With regard to the rejection of claims 1-26 under 35 U.S.C. §112, second paragraph, because "[t]here is no exact diode structure claimed," and "[t]he structure of the "diode" is vague and indefinite, and "[t]he language 'based' is vague and indefinite," Applicants' attorney has canceled claims 1-16, 18 and 25-26 and has amended claim 17 to overcome these rejections. However, Applicants' attorney nonetheless traverses the rejection by noting the recitation of "light emitting diode (LED)" in the claims and submits that this sufficiently recites the diode structure, because a person of ordinary skill in the art would know the structure of an LED.

With regard to the rejection of claims 1-26 under 35 U.S.C. §112, second paragraph, because "[t]he language 'an emitting layer' is indefinite as there is no structural relationship of

such layer (with any other layer?) in the indefinite 'diode' structure," Applicants' attorney has canceled claims 1-16, 18 and 25-26 and has amended claim 17 to overcome these rejections.

With regard to the rejection of claims 1-26 under 35 U.S.C. §112, second paragraph, because "[s]ize" is indefinite," Applicants' attorney has canceled claims 1-16, 18 and 25-26 and has amended claim 17 to overcome these rejections.

With regard to the rejection of claim 2 under 35 U.S.C. §112, second paragraph, Applicants' attorney has canceled claim 2.

With regard to the rejection of claim 16 under 35 U.S.C. §112, second paragraph, because "'epoxy on the structured surface' has no antecedent and is indefinite," Applicants' attorney has canceled claim 16.

With regard to the rejection of claim 17 under 35 U.S.C. §112, second paragraph, because "[c]laim 17 is vague and indefinite as no diode structure is defined, similar to claim 1," "[t]he language 'based' is indefinite," "[t]he language 'an emitting layer' is indefinite," "[the] language 'structuring' is indefinite," "[t]he language 'to enhance' is indefinite," and "[e]nhanced from what to what?," Applicants' attorney has amended claim 17 to recite a diode structure, to remove the term "based," to better define "an emitting layer," and to remove the phrase "to enhance." However, Applicants' attorney traverses the rejection regarding the diode structure by noting the recitation of "light emitting diode (LED)" in the claims and submits that this sufficiently recites the diode structure, because a person of ordinary skill in the art would know the structure of an LED.

Applicants' attorney also traverses the rejection of "structuring" as being indefinite, but nonetheless has amended claim 17 to overcome these rejections.

With regard to the rejection of claim 20 under 35 U.S.C. §112, second paragraph, because "n-type layer" has no antecedent and is indefinite," Applicants' attorney has canceled claim 20.

V. Prior-Art Rejections

On pages 3-5, the Office Action rejected claims 1-26 under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as being obvious over Palacios et al., S.S.T. 15 (2000) pp. 996-1000 (Palacios). On pages 5-6, the Office Action rejected claims 1-26 under 35 U.S.C. §103(a) as being obvious over Palacios in view of Motoki, U.S. Patent No.

6,468,882 (Motoki), Nishida et al., APL Vol. 79, No. 6, August 6, 2001, pp. 711-712 (Nishida) and Wong et al., APL 10/2000 Vol. 77 No. 18, October 30, 2000, pp. 2822-2824.

Applicants' attorney respectfully traverses these rejections in view of the amendments above and the arguments below.

Applicants' independent claim 17 now recites a method of creating a (B, Al, Ga, In)N light emitting diode (LED), comprising: fabricating at least an n-type layer, an emitting layer and a p-type layer of the (B, Al, Ga, In)N LED on a substrate; exposing a nitrogen face (N-face) surface of the n-type layer by removing the substrate from the layers; and etching the N-face surface of the n-type layer after the substrate is removed to create a plurality of cones having a size not smaller than 200 nm to increase extraction efficiency of light from the emitting layer out of the N-face surface as compared to the N-face surface without the cones.

Applicants' attorney submits that the references do not teach or suggest the limitations of Applicants' amended independent claim 17.

The Office Action, on the other hand, asserts the following:

> Claims 1-26, as best understood, are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Palacios et al, (P), of record.
>
> Palacios discloses an N-face of a GaN layer etched with KOH to form pyramids (cones) enhancing extraction of photoluminescent light. Claim 1 does not define any "diode" structure distinguishing over Palacios. The label "diode" in claim 1 does not inherently define a p-n junction in claim 1 and there is no p-layer claimed. There is no specific "diode" structure claimed and no distinction over Palacios. The very purpose of Palacios is to enhance extraction of light out of the structure, therefore the pyramids are designed to be of a "size" to enhance light extraction. Claim 1 reciting cone sizes for enhancing light extraction is prima facie obvious or anticipated over Palacios. Figure 1 of Palacios discloses etching depths up to 9000 angstroms. The photoluminescent light extracted out of the Palacios device peaks at 3.485 eV (approx. 3200 angstroms). Therefore Palacios discloses pyramids (cones) at least the size (height or depth) of the wavelength of emitted light. Claim 1 is rejected.
>
> *   *   *
>
> Claims 1-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Palacios in view of Motoki 6,468,882 and Nishida et al APL Vol. 79 No.6, August 6, 2001 "Efficient ... GaN and Wong et al October 30, 2000 "InGaN ... laser lift off".
>
> P discloses cones for enhanced GaN light emission. Motoki discloses c-

> plane GaN substrates for GaN based emitters as P as GaN substrates are better lattice matched to GaN emitters and enable contacts to GaN material. It would have been obvious to practice a GaN based substrate with cones from P. From Nishida p-n junction light emitting diode structure is obvious for GaN based devices. From Wong dry etching is obvious alternative etching for forming a grooves and p-n junction diode structure. all claims, as best understood, are obvious.
>
> Applicant's arguments filed 4/3/09 have been fully considered but they are not persuasive. Applicant argues P does not disclose cones the size of the wavelength of emitted light. First the wavelength is not definite, secondly, the recitation is new matter, and thirdly, P discloses emission of light wavelengths of the order of the cone size.
>
> Regarding the fabrication claims, the language "based" is indefinite, and contrary to the arguments, P discloses cone formation on the N-face by etching. The arguments are unpersuasive.
>
> Regarding n-type layers, LED diodes in the applied art teach n-type and p-type layers for LED emission structures, And P clearly discloses "cones" or pyramids on an N-face to enhance extraction of photons. The arguments are unconvincing of patentability.

Applicants' attorney disagrees with this analysis.

Moreover, Applicants' attorney submits herewith a Declaration under 37 C.F.R. §1.132 from Tomas Palacios, one of the authors of the Palacios reference, that explains the teachings of the Palacios reference.

The Palacios reference does not describe an LED structure, where an N-face surface of an n-type layer of the LED is exposed by removing the substrate from the LED's layers, and the N-face surface of the n-type layer is etched after the substrate is removed to create a plurality of cones having a size not smaller than 200 nm to increase extraction efficiency of light from the emitting layer out of the N-face surface as compared to the N-face surface without the cones.

Instead, the structure described in the Palacios reference is merely GaN on an AlN buffer layer on an Si substrate. In the Palacios reference, the GaN is a thick slab 0.5 - 2 microns thick (Palacios, page 997, column 1), which is about 1000 - 10,000 thicker than a quantum well.

In the Palacios reference, pyramids are formed on the surface of the GaN layer to increase the internal quantum efficiency. Consider, for example, the following discussion in the Palacios reference:

Palacios: Page 998, Column 2

Figure 5 shows the spectra of unetched samples (both A and B type), and three A-type samples etched at 40°C and 7.1 M for 10, 20 and 30 min (step depths of 140, 280 and 420 Å, respectively). The unetched samples present almost the same PL emission: a wide peak at ~3.468 eV, associated with the DBE excitonic transition under tensile stress conditions [15]. For increasing etching time, the PL peak in A-type samples shifts to higher energy, and two high energy transitions appear at 3.479 and 3.485 eV, which are, respectively, assigned to the FXA and FXB excitonic transitions [17]. In addition, the PL intensity is significantly enhanced with the etching time, up to a factor of 10 with times of 20 min or longer. This improvement of the optical quality of the layer is not degraded after long periods of exposure to the ambient atmosphere (several months), which eliminates that a oxide layer or dirt removal could be responsible for the enhancement of the PL intensity. **The energy shift and intensity enhancement can be explained by the relaxation of tensile strain during the formation of the pyramids, although a contribution from quantum confinement in the nanostructures cannot be discarded.** Also, the presence of pyramids and the characteristics of the PL may indicate spatially inhomogeneous light emission. These observations contrast with PL measurements of GaN layers after a dry etching process (either by reactive ion etching, RIE [18], or by chemical-assisted ion beam etching, CAIBE [19]), where the PL signal is degraded

The increase in the PL intensity observed in the Palacios reference after forming the pyramids should be attributed to an increase in surface emission of the GaN film, which means that there is an increase of the internal quantum efficiency of the surface area of the GaN film by forming the pyramids at the surface. However, this increase of the PL intensity is not related to an increase in light extraction efficiency.

Applicants' claimed invention, on the other hand, is directed to an increase in the extraction efficiency of light, not internal quantum efficiency. This is accomplished by etching an exposed N-face of an n-type layer of an LED, as recited in Applicants' claims, not by etching a growth surface of a GaN layer, as shown in the Palacios reference.

Moreover, the size of pyramids in the Palacios reference is too small a value to improve the extraction efficiency of the light. Consider the following relevant portions of the Palacios reference:

Palacios: Figure 4

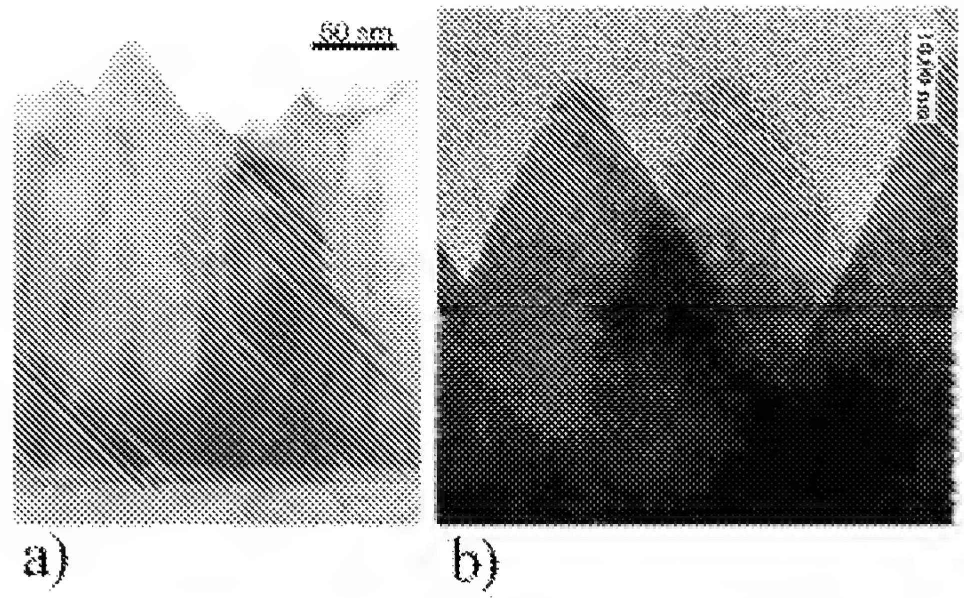

Figure 4. (*a*) Cross-sectional TEM multibeam image of a KOH-etched sample (30 min, [KOH] = 7.1 M at 40 °C). Note that the pyramidal nanostructures are not associated with structural defects. (*b*) High-resolution cross-sectional TEM image of the same sample.

Palacios: Figure 5

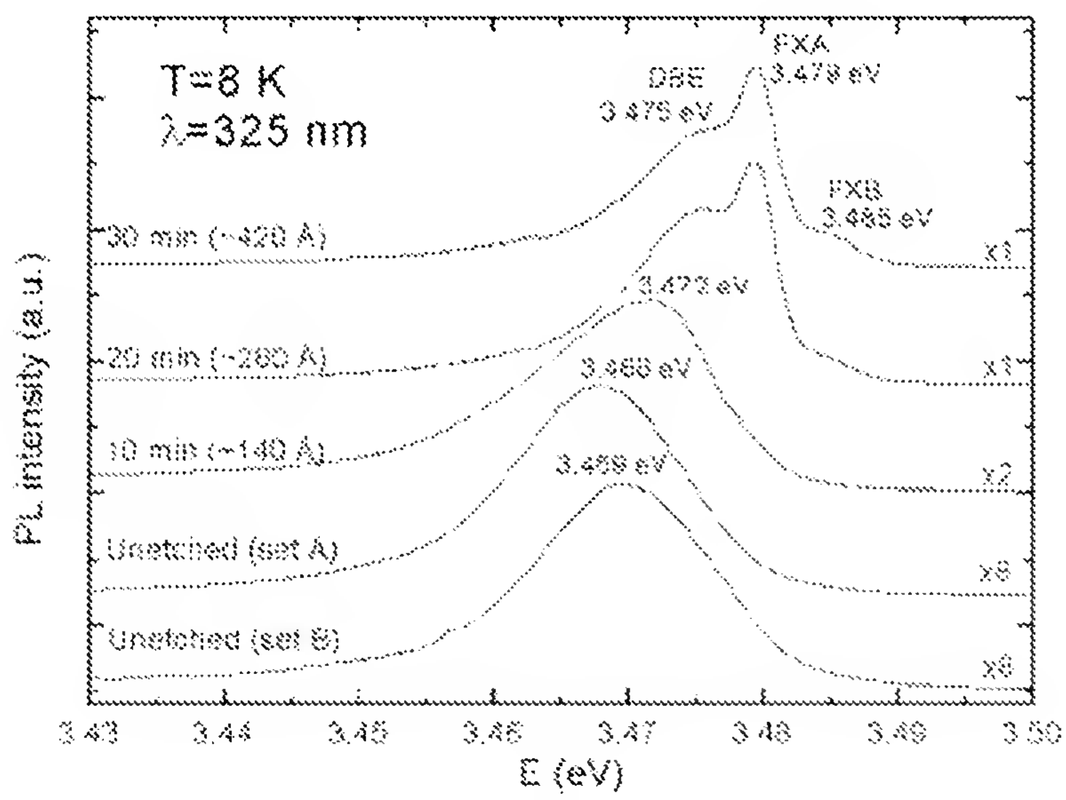

Figure 5. Low-temperature PL spectra of unetched thin AlN-buffered GaN and GaN etched in KOH: 7 M at 40 °C for 10, 20 and 30 min. The spectra of an unetched thick AlN-buffered GaN (type B) is also shown for comparison.

Palacios: Page 998, Column 1

Figure 4(a) presents a cross-sectional TEM multi-beam image of an etched sample (30 min in a 7.1 M KOH aqueous solution at 40 ∘C). As a consequence of the etching, triangular features covering the surface of the films are generated, although no preferential etch along columnar defects or associated with surface undulations is obtained. **Figure 4(b) shows a high-resolution cross-sectional TEM image of the etched sample.** The angle between the basal plane (parallel to the substrate) and the surface features in the etched samples is close to 60∘, indicating that these features are pyramids limited by {11-21} planes, as confirmed by selected area diffraction patterns. The pyramids are monocrystalline and they all show the same orientation relationship with the crystal structure. In agreement with previous observations [8], {11-21} planes are therefore more resistant than {10-1n} planes to the etching.

Palacios: Page 998, Column 2

Figure 5 shows the spectra of unetched samples (both A and B type), and three A-type samples etched at 40°C and 7.1 M for 10, 20 and 30 min (step depths of 140, 280 and 420 Å, respectively). The unetched samples present almost the same PL emission: a wide peak at ~3.468 eV, associated with the DBE excitonic transition under tensile stress conditions [15]. **For increasing etching time, the PL peak in A-type samples shifts to higher energy, and two high energy transitions appear at 3.479 and 3.485 eV, which are, respectively, assigned to the FXA and FXB excitonic transitions [17].** In addition, the PL intensity is significantly enhanced with the etching time, up to a factor of 10 with times of 20 min or longer. This improvement of the optical quality of the layer is not degraded after long periods of exposure to the ambient atmosphere (several months), which eliminates that a oxide layer or dirt removal could be responsible for the enhancement of the PL intensity. The energy shift and intensity enhancement can be explained by the relaxation of tensile strain during the formation of the pyramids, although a contribution from quantum confinement in the nanostructures cannot be discarded. Also, the presence of pyramids and the characteristics of the PL may indicate spatially inhomogeneous light emission. These observations contrast with PL measurements of GaN layers after a dry etching process (either by reactive ion etching, RIE [18], or by chemical-assisted ion beam etching, CAIBE [19]), where the PL signal is degraded

Based on the legend in Figure 4(b), it appears that "pyramidal nanostructures" of the Palacios reference may have a size (height or depth) of about 60 nm. As shown in Figure 5, this 60 nm size results from a 30 minute etch using a step depth of 420 Å resulting in a peak high energy transition of 3.485 eV (approximately 3200 Å per the Office Action, which is equivalent to 320 nm).

This is also supported by the Declaration under 37 C.F.R. §1.132 by Tomas Palacios. The Declaration confirms that the pyramidal nanostructures in the Palacios publication have a size (height or depth) of about 60 nm. (Also, the Declaration states that peak high energy transition of 3.485 eV is approximately 3558 Å, which is equivalent to a wavelength of light of approximately 356 nm, rather than 3200 Å and 320 nm per the Office Action.)

In Applicants' claims, however, the cones have a size not smaller than 200 nm. In order to enhance light extraction, the size of the cone-shaped structures should be close to the wavelength of the light in the LED:

> Applicants' specification: page 11, line 20
>
> The cone-shaped surface appears very effective for light extraction from the LED. Moreover, experimental results suggest that a cone shape can extract more light. **For example, the wavelength of a blue LED in a GaN crystal is about 200 nm. If the size of the cone shape is much smaller than that value, then the light might not be affected by the roughness. On the other hand, if the size of the cone shape is close to that value, the light might be scattered or diffracted.**
>
> Applicants' specification at page 4, line 5:
>
> On the other hand, in the present invention, utilizing flip-chip technology [14] and the LLO method, a substrate-free nitrogen (N) side-up GaN-based LED structure can be made. **Thereafter, an anisotropic etching process can be used to roughen the surface of the N-side-up GaN-based LED. This results in a hexagonal "cone-like" surface, which is beneficial for light extraction. Extraction efficiency of an optimally roughened surface LED shows an increase by more than 100% compared to an LED before roughening.**

Thus, the pyramidal nanostructures in the Palacios reference with a size of 60 nm would have a negligible effect, if any, on extraction of emitted light at 320 nm (or 356 nm).

Finally, the combination of the Palacios reference with the Motoki, Nishida and Wong references does not render Applicants' invention obvious. Recall that the Motoki reference merely discloses c-plane GaN substrates; the Nishida reference merely discloses AlGaN ultraviolet LEDs grown on bulk GaN; and the Wong reference merely discloses the use of laser lift-off to separate GaN from a sapphire substrate in the fabrication of LEDs. However, this proposed combination would be inoperable as it relates to Applicants' invention.

For example, Wong's discussion of the use of laser lift-off to separate GaN from a sapphire substrate in the fabrication of LEDs occurs in the context of transferring the GaN from

the sapphire substrate to an Si substrate (which is used as a backside p-contact). However, a person of ordinary skill in the art would not etch the exposed surface of the GaN, after the sapphire substrate has been removed but before the Si substrate has been bonded, in the manner suggested by the Office Action, because it would defeat the purpose of the etching, namely to increase extraction efficiency of light out of the exposed surface, because light could not be extracted through the Si substrate after the etched surface of the GaN is bonded to the Si substrate. Indeed, the bonding of the etched surface of the GaN to the Si substrate would likely destroy the resulting structures on the etched surface of the GaN.

Such inoperability runs counter to the decision in KSR v. Teleflex, 550 U.S. 398, 127 S. Ct. 1727 (2007), which notes that, in determinations of obviousness under 35 U.S.C. §103(a), there must be some motivation to combine references. M.P.E.P. §2143.01(V) states that if a proposed modification would render the prior art invention unsatisfactory for its intended purpose (e.g. by compromising its operability), then there is no suggestion or motivation to make the proposed modification. Consequently, the Palacios reference cannot be combined with the Wong reference in the manner suggested by the Office Action.

In summary, Applicants' attorney submits that amended independent claim 17 is allowable over the references. Further, dependent claims 20-24 and 27-34 are submitted to be allowable over the references in the same manner, because they are dependent on the independent claim 17, and thus contain all the limitations of the independent claims. In addition, dependent claims 20-24 and 27-34 recite additional novel elements not shown by the references.

VI. Conclusion

In view of the above, it is submitted that this application is now in good order for allowance and such allowance is respectfully solicited. Should the Examiner believe minor matters still remain that can be resolved in a telephone interview, the Examiner is urged to call Applicants' undersigned attorney.

Please consider this a PETITION FOR EXTENSION OF TIME for a sufficient number of months to enter these papers, if appropriate. Please charge all fees to Deposit Account No. 50-0494 of Gates & Cooper LLP.

Respectfully submitted,

GATES & COOPER LLP
Attorneys for Applicants

Howard Hughes Center
6701 Center Drive West, Suite 1050
Los Angeles, California 90045
(310) 641-8797

Date: October 7, 2009

By:/George H. Gates/
Name: George H. Gates
Reg. No.: 33,500

GHG/

G&C 30794.108-US-WO